The remainder of this section of the Annex addresses the points brought up by AMSC on a point-by-point basis.

1.1 Radio Astronomy

In its application Odyssey explained how avoidance of interference to Radio Astronomy sites would be implemented[2]. AMSC apparently doesn't dispute TRW's showing that Odyssey ground based users can be operationally controlled to avoid potential interference to the Radio Astronomy hydroxyl line measurements. It directs its comments only to the case of airborne Odyssey users. AMSC's argument is based on the calculations in Table 8 of its AMSC Technical Annex. The table purports to show that the combined emissions from Odyssey users, at an altitude of 20,000 meters and at 406 miles from a Radio Astronomy site would just equal the AMSC derived protection limit for a Radio Astronomy system making measurements on the hydroxyl line.

AMSC has "derived" a protection limit for Radio Astronomy that is 10 dB lower than the limit specified in Report 224-7. CCIR Report 224-7 indicates that a permissible level of interference to the Radio Astronomy observatory, for this band, is -220 dBW/m^2 in a 20 kHz bandwidth. AMSC, in Table 8 to the Technical Appendix, utilizes a figure of -230 dBW/m^2 in the reference bandwidth. As a result, AMSC has overstated the potential for interference to Radio Astronomy. Many types of communications systems can co-exist given the acceptance of some types of operational constraints on one or both systems. TRW has already described how it can operationally constrain its users so that Odyssey can share with Radio Astronomy, and the constraints to be utilized by TRW will not affect the viability of its system.

In any event, AMSC's assumptions are incorrect. If in coordinating with the Radio Astronomy community, a 400 mile airborne coordination radius were determined (and the discussion below indicates that any airborne coordination distance would be

[2] Odyssey Application Erratum, Appendix C, pp C -4 - C-6.

smaller that 400 miles), the result would be far from catastrophic. The six RA sites listed in the Gen. Docket Nos. 84-689 and 84-690 include two sites in California and one each in New Mexico, Texas, West Virginia and Puerto Rico. A 400 mile coordination distance surrounding these six sites would hardly preclude Odysseys use "of the lowest proposed sub-band... over most of CONUS"[3] . First, these coordination distances would be in effect only when hydroxyl measurements were being made and secondly, the impact would be only to the airborne users of Odyssey, which are expected to be a relatively small percentage of the total user population. The impact on the Odyssey system's operation would be minor and controllable.

A mentioned above, in its analysis, AMSC reduced the stated permissible interference limit to Radio Astronomy by 10 dB. In addition, they have neglected signal blockage by the aircraft airframe. Since, the Odyssey system operates at elevations above 30°, the antenna would be mounted on the upper surface of the aircraft and some blockage below the horizontal plane would naturally occur. In addition, they have resorted to using an aircraft altitude of 20,000 meters[4]. This altitude is in excess of 65,000 feet, an altitude used only by a very few specialized military aircraft.

1.2 Fixed and Mobile Services:

1.2.1 Current U.S. Terrestrial Usage of the 2483.5-2500 MHz band

In its Report and Order dealing with the RDSS service, the FCC detailed the usage of this band at the time of the Report and Order, and froze the addition of new terrestrial operations by stating that "Applications for additional terrestrial operations filed after July 25, 1985 will be dismissed as not in compliance with the new allocation for this band"[5]

The band usage was described as : "At the time of the [RDSS] Notice there were about 70 mobile and fixed stations used for electronic news-gathering operations

[3] Opposition of AMSC, Technical Appendix at 12

[4] Opposition of AMSC, Technical Appendix, Table 2, Note 4

[5] FCC Gen. Docket 84-690, RDSS Report and Order, Para 20, page 1421

(ENG) and for studio-to-transmitter links. Also, there were about 21 private radio licensees operating in this band under Parts 90 and 94"[6]

The typical fixed system usage in this band is for industrial short haul or temporary fixed stations, and for studio-transmitter links (STL). A temporary fixed station is licensed in a general area of operations and normally stays at one location for a period of time, e.g., six months, before being moved. The typical mobile service usage is for ENG links. In the ENG usage, the 2484-2500 MHz band is one of a number of channels involving frequencies down to 1990 MHz.

In the RDSS Report and Order, the FCC grandfathered " all fixed and temporary stations in the 2483.5-2500 MHz band on a primary basis to RDSS licensees."[7] and grandfathered "all existing mobile licensees in the 2483.5-2500 MHz band also on a primary basis with one condition. If interference from these grandfathered mobiles is determined to be unacceptable [to the RDSS system], we are providing RDSS licensees the option of paying the reasonable and prudent cost of modifying an existing licensee's operation. We believe the primary status afforded both RDSS and mobile licensees in this band provides a firm basis for negotiations among affected parties..."[8]

The important point to note is that the 2483.5-2500 MHz frequency was not heavily used when the RDSS allocations were made, in 1984, and no growth has been allowed in the band since that time.

1.2.2 Discussion

As mentioned above, there are at least three distinct types of terrestrial operations taking place in the 2483.5-2500 MHz band; mobile as typified by the ENG operations, industrial temporary fixed, and fixed as typified by the STL links. The effect of

[6] FCC Gen. Docket 84-690, RDSS Report and Order, Footnote 10, page 1420
[7] FCC Gen. Docket 84-690, RDSS Report and Order, Para 18, page 1421
[8] FCC Gen. Docket 84-690, RDSS Report and Order, Para 19, page 1421

increasing the PFD from the Odyssey satellites will depend upon the type of operation.

It should be noted that AMSC overstates TRW's request for a PFD waiver. "In its Petition, TRW proposes a 10 dB relaxation of the current power flux density ("PFD") limits"[9], implying that a general 10 dB increase in PFD has been requested. The TRW waiver would actually increase the PFD for high angles of arrival by 5 dB (from -144 to -139 dBW/m^2 4 kHz, for angles of arrival greater than 25 degrees) and for a zero degree angle of arrival by 7 dB (from -154 to -147 dBW/m^2 4 kHz). The maximum difference between the requested waiver and the current limit would occur only at an angle of arrival of 5 degrees and is 9.5 dB. Thus, TRW has not requested a 10 dB increase in PFD for all angles of arrival.

1.2.2.1 Mobile Operations

Typical ENG mobile operations are carried out on a temporary basis and last for the length of time that the news event or sports contest occurs. For significant interference power to enter the mobile system, one of the Odyssey satellites must appear near the main beam of one of the mobile receivers and the mobile system must be operating on the one channel (out of the 10 Television Auxiliary Broadcast channels in this part of the spectrum) that the Odyssey satellites will occupy.

A search of the FCC non-government files indicates that these stations generally use antenna gains in the 20 to 30 dBi range, not the 37 dBi used in the AMSC analysis. This reduced gain should lead to a smaller required off-axis discrimination angle than shown by AMSC. For sake of argument, however, if the 3.5° discrimination angle calculated by AMSC for analog traffic is used (FM-TV modulation is typically used with these systems) a single Odyssey satellite would be outside of this discrimination angle for some 99.8%[10] of the time. For the maximum of three Odyssey satellites that can be simultaneously in view, the percentage of time that one will be within this discrimination angle is about 0.37%. During this small percentage of the

[9] AMSC Opposition, Technical Appendix at 14.

[10] Based on the ratio of the area of a hemisphere to that encompassed by a geocentric angle of 3.5°.

time, the mobile system affected could operate on one of the other nine channels available. This would indicate that the grandfathered mobile system should not suffer unduly from a relaxation of the S-Band PFD limit.

1.2.2.2 Temporary Fixed Operations

The temporary fixed operations are industrial communication links that are usually related to petroleum industry operations. The links are put into place for a period of six months to a year and then moved to new locations. The susceptibility of one of these links to interference is, among other things, a function of the system margins that exist under faded conditions and the percentage of time that fades occur. If these system also have a 3.5° discrimination requirement, as suggested by AMSC, then they could receive power levels above the permissible level for the same percentages of time as the mobile system discussed above. Whether or not exceeding the level of permissible interference causes an actual interference outage depends on the fade conditions of the circuit.

Since these links are broken down and set up at intervals, one possible solution would be to set the links up to have a larger fade margin. Basically, this would require shorter hop(s) within the system. A second possibility would be to use path diversity links. With the temporary fixed system pointed near the horizon, only a single Odyssey satellite could be near the pointing azimuth of the terrestrial system. A second path, pointed a few degrees away from the first, could not simultaneously receive significant external power from an Odyssey satellite. Therefore one of the two paths would be free from potential interference from the Odyssey system.

1.2.2.3 Fixed Systems

Fixed systems in this band are typified by STL links. These are short systems with, at most, a few microwave hops. These systems could be modified in a similar manner to the temporary fixed systems to reduce any possible effect from the Odyssey system.

1.2.2.4 General

Because of the types of terrestrial usage being made of the 2483.5-2500 MHz frequency band, TRW does not believe that any actual harm would be caused by granting the requested change in PFD crieteria. Certainly, the case made by AMSC is significantly overstated. However, TRW is ready and willing to work with the current U.S. terrestrial users of this band to reach an equitable solution to any problems that might arise.

1.2.2.5 World Wide Usage

The majority of international uses of the 2483.5-2500 MHz band parallels that of the U.S. This is not to say that there are not exceptions, but the exceptions are in the minority. During the 1988 WARC, only Italy indicated that it had a terrestrial system of significant length.

1.3 Radionavigation Service

A preliminary analysis of the potential for interference from an Odyssey user terminal into a Glonass receiver is presented in Table 1. The Odyssey user EIRP, used in Table 1, is taken from the TRW Erratum, at C-3, and is the expected weighted average EIRP for all users in the the system. The Table shows that with a distance of 10 km separating the Glonass receiver and Odyssey user unit, there is no interference to the Glonass receiver. Interference to a Glonass receiver, if it occurs, would occur at separation distances much less than 10 km. Therefore, the preliminary conclusion is that any interaction between Glonass and Odyssey would occur with a very low probability.

1.4 RDSS Service

AMSC is concerned about possible interference to the GSO RDSS systems in the 2483.5 to 2500 MHz band. It states, without showing any technical basis, that "Odyssey will substantially reduce the capacity of geostationary RDSS systems"[11] because of the request to raise the PFD limits. In actual fact, the GSO RDSS

[11] Opposition of AMSC, Technical Annex at 18

application submitted by the Geostar Corporation proposed a "Maximum PFD of -139.0 dBW/m^2/4 kHz"[12] . The obvious conclusion is that a GSO RDSS system would take advantage of any increase in PFD and therefore actually increase its capacity. As Odyssey has already pointed out[13] , an increase in PFD limits permits more users to operate on a given region of the Earth before the inter- and/or intra-system code noise limits the performance of all of the spectrum sharing systems. The GSO RDSS system, to the extent one exists, would benefit from an increase in PFD just as the LEO RDSS systems would.

Table 1 Analysis of Interference into Glonass receiver

Odyssey Average User EIRP	2.4	dBW
Transmission Bandwidth	67.0	dBHz
Range	10.0	km
Free Space Loss	-116.6	dB
Excess Path Loss[14]	76.0	dB
Total Loss	-192.6	dB
Receive Antenna gain	2.0	dBi
Receive Power	-257.2	dBW/Hz
Boltsmann's constant	-228.6	dBW/K-Hz
Equivalent Noise Power	-28.6	dBK
Equivalent Increase in Noise Power	0.00	K

1.5 MSS Service

AMSC states that "TRW completely overlooks the fact that the 1610-1626.5 MHz band may be used for geostationary MSS systems." At the time the Odyssey RDSS application was submitted, the only mention of MSS operations in the RDSS frequency bands contained in the U.S. proposals were limited to those systems

[12] Geostar Satellite System Compendium and Application and Technical Information, April 5, 1985, Appendix 2, Page 7, Table 1

[13] See Attachment to the Odyssey Petition for Rule Making and Request for Pioneer's Preference, July 8,1991

[14] Lucien Bothias' model for excess loss over free space is used with an antenna height of 2 meters. see Radiowave Propagation, North Oxford Academic Publishers, 1987

meeting the CCIR criteria of an earth station transmit power restriction of -3 dBW/4 kHz. Since this restriction precludes AMSC-type systems, AMSC's proposal was not in accordance with the US proposals to the WARC, and thus was not addressed.

It should be noted that AMSC's analysis indicates that a geostationary MSS satellite, of AMSC's design, would receive interference from an Odyssey system that is not even fully loaded. It claims that the Odyssey system would "result in complete disruption of MSS communications via geostationary satellites"[15]. TRW has already shown that Odyssey is compatible with GSO RDSS systems and that it meets the GSO PFD criteria adopted by the RDSS Coordinating Committee. The fact that the AMSC-designed GSO Mobile Satellite Service system is incompatible with Odyssey implies that is it would also receive unacceptable interference from a GSO RDSS system operating at or near the GSO PFD limit. AMSC is therefore emphasizing the point that its system is not "compatible" with GSO RDSS systems and therefore its application is not in conformance with the U.S. Proposals to the 1992 WARC.

1.6 Capacity

The PFD analysis given previously by TRW[16] indicated that the current PFD limit would constrain a generic CDMA RDSS/MSS system to about one-half of the number of users that the same system could support at higher PFD limits. This is the reason for requesting that the current PFD limits be relaxed. Table 2 addresses the number of users the Odyssey system could support at the current PFD limit.

The Odyssey application estimated that some 4600 users could be served by the Odyssey system in a given region. The results of Table 2 show that slightly more than 2000 users can be simultaneously supported at the current PFD limit. This is the order of magnitude predicted from the earlier analysis.

The values derived by AMSC, in Table 12 of the AMSC Technical Appendix,

[15] AMSC Opposition, Technical Appendix, Page 18

[16] Attachment to TRW Petition for Rule Making and Request for Pioneer's Preference July 8, 1991

contain some false assumptions by AMSC that have already been addressed. For example, "Reduction in capacity from confinement of uplinks to 1616.5 to 1626.5 = 0.5806". Since sharing with the Radio Astronomy Service is feasible, this reduction factor is actually zero. "Reduction in capacity from conformance with current PFD limit = 0.1995". This is actually about 0.5, as explained immediately above and shown in Table 2. AMSC has made some other totally unfounded assumptions concerning the Odyssey system. See in particular, Note 1 where AMSC has restructured the Odyssey channel plan based on its assumption that Odyssey can not share with Radio Astronomy, and Note 2, where AMSC asserts that the PFD from Odyssey to should be 10 dB below the current PFD limits in order to protect fixed systems. The current PFD limits, for low angles of arrival, already consider one mainbeam coupling into a long-line microwave relay system[17], so there is no basis for assuming that a further reduction in PFD is required.

[17] "The derivation of the present satellite power flux-density limitation assumes one radio-relay station in a 50-hop system will have a direct exposure to a Geostationary satellite, and the remaining stations will have sufficient antenna discrimination that the additional interference is not significant. On this premise the flux-density limit for a tangential ray was established", Bell System Technical Journal, January 1971, Model for Computation of Interference to Radio-Relay Systems From Geostationary Satellites, A.S. May and M.J. Pagones.

Table 2 - Number of Users Supported at the Current PFD Limit

RF Power per user	0.50	W
RF Power per user	-3.01	dBW
Antenna Gain (EOC)	25.44	dBi
Satellite EIRP (EOC)	22.43	dBW
Antenna Gain Correction	3.00	dB
Satellite EIRP per User (Mainbeam)	25.43	dBW
Range	10239	km
Spreading Loss	-151.2	dB/m^2
PFD (per User)	-125.8	dBW/m^2 in 5 MHz
Bandwidth Conversion	31.0	dB
PFD (per User)	-156.7	dBW/ m^2 4 kHz
Existing PFD Limit	-144.0	dBW/ m^2 4 kHz
PFD Margin (Single User)	12.7	dB
Number of Simultaneous Users per Beam	19	Users
Voice Activation Factor	0.35	
Number of Users per Beam	54	Users
Number of Users per Satellite (19 Beams)	1019	Users
Two Satellites per coverage region	2039	Users

2.0 Response to Motorola

Motorola states that "TRW argues that voice service can not be offered in this band [2483.5-2500 MHz] unless these PFD limits are relaxed"[18]. This is not true. As shown in Table 2, the Odyssey single user PFD for the operation of a digital voice service is on the order of -156.7 dBW/m^2 4 kHz. This value is below the existing PFD limit. The reason TRW has requested a relaxation of the current PFD limits is to increase the number of system users available to the compatible MSS/RDSS applicants and to ensure sufficient users for a viable multiple entry policy. By granting the requested change in the PFD limit, the Commission would effectively double the number of users that could be served by the CDMA RDSS/MSS applicant systems. This increase of the user base means more economic room for competition and better communication systems for the public. Maintaining the current PFD limits would not preclude the operation of a system like Odyssey but it would constrain the possible competition that could develop in a multiple entry environment. In effect a higher PFD creates a larger economic resource pool to be shared between the current applicants and possible future entrants.

Motorola also states that " The proposed [PFD] levels are based on service to mobile units with directional antennas. Handheld units will require satellite downlinks with significantly higher power flux densities (about -120 dBW/4 kHz), in order to account for environmental shadowing effects and the use of omnidirectional antennas"[19]. This statement is also unsupported by the facts. TRW has supplied a number of link budgets for the Odyssey system (see Tables B-1 to B-10 of the TRW Erratum). These link budgets deal with both the service and order wire links under faded and non-faded conditions. In all cases addressed in these tables the user antenna gain is assumed to be 2.5 dBi, i.e. an omnidirectional antenna. The handheld units, operating at 0.5 watts of RF power, are specifically addressed in a number of the link budgets.

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[18] Motorola Comments at 14.

[19] Id.

The PFD level quoted by Motorola (i.e., -120 dBW/4 kHz) is unsupported by any analysis. One factor which Motorola may have overlooked, is that unlike Iridium, the Odyssey system can operate exclusively at elevation angles above 30 degrees. The Iridium system plans to operate down to elevation angles as low as 5 degrees and therefore requires a significantly higher link margin than the Odyssey system.

TECHNICAL CERTIFICATE

I, Paul Locke, hereby certify that I am the technically qualified person responsible for the preparation of the technical information contained in the foregoing Technical Annex to the Comments of TRW Inc. Under penalty of perjury, the technical information presented is complete and accurate to the best of my knowledge.

Dated this 13th day of November 1991

By: Paul Locke

Paul Locke
President
LT Engineering Inc

CERTIFICATE OF SERVICE

I, Katharine K. Bryant, do hereby certify that a copy of the foregoing "Reply Comments of TRW Inc." was mailed, first-class postage prepaid, this 14th day of November 1991, to the following:

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